Global Innovations in Materials and Technologies for Energy Harvesting

Sivaraman Guruswamy, Joy A. Forsmark, and Robert Hyers

Sivaraman Guruswamy

Joy A. Forsmark

Robert Hyers

Increasing energy demand combined with concern for the impact of fossil fuels on the environment has led to increased interest in alternative energy sources. The primary source of renewable energy resources as well as fossil fuel resources is solar radiation. The radiation from the sun powers the photosynthesis process that combines carbon dioxide and water to form oxygen and vegetation. This radiation also sustains the wind currents, ocean waves, hydro- and geothermal systems, and life forms in the oceans and on land.

The energy needs of modern society for electric power generation, automotive, commercial and residential use, and transportation is ~15 TW, less than 3% of the 510 TW solar radiation incident on Earth. Efficient and economical harvesting of this renewable energy using solar cells, wind turbines, and geothermal power systems without influencing the wind, weather, and rainfall patterns across the world is the challenge we face as a society. The Global Innovations symposia on Materials and Technologies for Energy Harvesting, and Photovoltaics and Thermoelectrics were organized by the Materials Processing & Manufacturing Division at the TMS 2009 Annual Meeting in San Francisco to highlight energy resource assessments and key issues that need to be addressed in technologies for large-scale energy harvest-

ing from renewable energy sources and waste heat sources.

The symposia featured speakers who are leaders in academia, government, and industry. In this issue, three papers presented in the

symposia are highlighted. In the first paper, Bhakta Rath, Associate Director of the Naval Research Laboratory, provides an overview of various energy resources of the Earth and technologies and materials issues involved in harvesting these energy resources, with special focus on energy derivable from the ocean.

In the second paper, Distinguished Professor Mildred Dresselhaus of the Massachusetts Institute of Technology and her collaborators examine the design of nanostructured bulk composite thermoelectric materials appropriate for devices used in large-scale waste energy harvesting from buildings, automobiles, and other waste heat sources, and in photovoltaic and thermophotovoltaic applications.

In the third paper, Jean-Pierre Fleurial of the NASA Jet Propulsion Laboratory examines novel advanced bulk thermoelectric materials and flexible lower-cost modular arrays capable of long-term operation at temperatures up to 1,300 K with more than 20% conversion efficiency for use in deep-space missions and terrestrial applications.

Three of the plenary talks presented but not included in this issue deal with photovoltaics, wind energy, and artificial photosynthesis. In his plenary talk "Solar Photovoltaics Technology: The Beginning of the Revolution," Larry Kazmeski, Director of the National

Photovoltaics Center at NREL, provided insights into the evolution of this technology. The presentation reviewed R&D advances in cell design, materials, module options, the status and forecasts for next-generation PV systems based on organics, nanotechnologies, and non-conventional junction approaches. Shu-Ching Quek and Stephan Renou of GE Global Research discussed the combination of material development and process improvements needed for more efficient blades and cost-effective, lightweight, reliable larger megawatt class wind turbines that would allow expansion of wind sites to lower wind speed locations. Graham Fleming, of the University of California at Berkeley and Lawrence Berkeley National Laboratory, provided insight into the design principles responsible for the remarkable efficiency of natural photosynthetic light harvesting. A key invited paper by Takao Mori describes the development of boron-rich p-type $\text{REB}_{44}\text{Si}_2$ and n-type RE-B-C(N) cluster thermoelectric compounds exhibiting melting points above 2,200 K that his team has discovered. The invited presentation by N.B. Singh and coworkers from Northrop Grumman examined the effect of growth of PbSe nanocubes and nanodots with band gaps closely matched to the solar spectrum. Eight key contributed papers focused on recent photovoltaic and thermoelectric material developments were also featured in the symposia.

Sivaraman Guruswamy, Professor, is with the Department of Metallurgical Engineering, University of Utah, 135 South 1460 East, Room 412, Salt Lake City, UT 84112; Joy A. Forsmark, technical expert, is with Ford Motor Co., Dearborn, MI 48121; and Robert Hyers, Associate Professor, is with the Mechanical Engineering Department, University of Massachusetts, Amherst, MA 01002. Dr. Guruswamy can be reached at s.guruswamy@utah.edu.